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Failures to Ignore Entirely Irrelevant Distractors: The Role of Load

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In daily life (e.g., in the work environment) people are often distracted by stimuli that are clearly irrelevant to the current task and should be ignored. In contrast, much applied distraction research has focused on task interruptions by information that requires a response and therefore cannot be ignored. Moreover, the most commonly used laboratory measures of distractibility (e.g., in the response-competition and attentional-capture paradigms), typically involve distractors that are task relevant (e.g., through response associations or location). A series of experiments assessed interference effects from stimuli that are entirely unrelated to the current task, comparing the effects of perceptual load on task-irrelevant and task-relevant (response competing) distractors. The results showed that an entirely irrelevant distractor can interfere with task performance to the same extent as a response-competing distractor and that, as with other types of distractors, the interfering effects of the irrelevant distractors can be eliminated with high perceptual load in the relevant task. These findings establish a new laboratory measure of a form of distractibility common to everyday life and highlight load as an important determinant of such distractibility.

Keywords: perceptual load, distractor interference, distraction at work, distraction during driving, attention

Being distracted in daily life can interrupt task performance and have a variety of negative consequences. A good illustration of this can be found in research highlighting the many disadvantages experienced by highly distractible individuals: Not only do they show poorer academic performance as schoolchildren (Rabiner, Murray, Schmid, & Malone, 2004) and reduced efficiency in the workplace as adults (J. C. Wallace & Vodanovich, 2003), but they also have increased risk of both minor (e.g., losing work while computing, Jones & Martin, 2003) and more serious accidents (e.g., car accidents or serious falls, Arthur & Doverspike, 1992; Larson, Alderton, Neideffer, & Underhill, 1997; Larson & Merritt, 1991). A valuable application of attention research would therefore be to predict the type of stimuli that are likely to distract performance even when completely irrelevant to the task at hand and characterize the type of tasks that are more vulnerable or more immune to distraction. In this way attention research can identify potential ways of avoiding the interfering effects of irrelevant distractions.

However, despite much previous work on attention and distraction, the form of distraction by stimuli that are entirely irrelevant to the task at hand has been rather understudied. Such irrelevant distractions seem common to daily life and the work environment. For example, in work environments one may be distracted by irrelevant noise or by the actions of a colleague nearby. During driving, one may be distracted from focusing on the road ahead by a colorful roadside billboard, despite the billboard appearing in a location to which the driver has no reason to attend, and being entirely unrelated to the task of driving. Indeed, such distractions can be associated with serious negative outcomes. For example, electrical workers that report being more distracted in daily life are more likely to suffer from accidents at work (Wallace & Vodanovich, 2003). Increased rates of car accidents have been associated with sections of road with greater numbers of roadside billboards (see B. Wallace, 2003, for review), and a recent study (McEvoy, Stevenson, & Woodward, 2007) found that over 10% of a sample of 1,367 drivers hospitalized following a car accident reported having been distracted at the time of the crash by seemingly task-irrelevant factors such as the sight of a person, event, or object outside of the car or an animal or insect inside the car.

Much applied research into distraction has focused on secondary-task interference, whereby distracting effects result from deliberately dividing attention between two or more tasks (e.g., having a mobile phone conversation while driving; Strayer & Drews, 2007). As attention is deliberately allocated to the source of distraction in order to perform the secondary task, however, this research does not address the issue of interference from any form of irrelevant distractors that should be ignored, such as those in the aforementioned examples of driving or the work environment.

Another area of applied research that that bears on the issue of distraction has examined task interruptions and their management (e.g., a pilot may be interrupted from ongoing tasks by instructions of air-traffic control) in a wide range of work environments such as air-traffic control, driving, and computing (see Gillie & Broadbent, 1989; Hodgetts & Jones, 2006; Jackson, Dawson, & Wilson, 2003; Latorella, 1998; McFarlane & Latorella, 2002; Noy, Lemoine, Klachan, & Burns, 2004; Trafton, Altmann, Brock, & Mintz, 2003). However, the task interruptions in this research are not made by stimuli that are clearly task irrelevant. In fact, the task

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interruptions examined were those that force the person to allocate some attention to the source of interruption, in order to either make a response or determine whether or not to respond (e.g., a pilot may have to respond to the air-traffic controller).

Thus, like the secondary-task interference research the interruption-management research also cannot tell us about the determinants of the ability to ignore distractors that are clearly irrelevant to the current task—in fact, ignoring the interrupting information in these tasks would be at least in some cases contrary to the participant's goals. In contrast, the issue of irrelevant distractions concerns the ability to avoid any interruption by a potentially distracting stimulus that is clearly task irrelevant.

The effects of irrelevant distraction have been more directly addressed in research into the effects of irrelevant noise on task performance (see Broadbent, 1979; Smith, 1990 for review). This research has revealed valuable information about the characteristics of noises that are more distracting (e.g., a change in the level of noise, even from louder to more quiet, is in many cases more distracting than continuous noise, Teichner, Arees, & Reilly, 1963) and those that in fact produce some alerting effects and thus facilitate rather than hinder performance. However, both the magnitude and the direction (whether interfering or facilitating) of effects of noise on performance appear to be highly task dependent (e.g., negative effects of moderate noise have often tended to be found on tasks with a high cognitive load, whereas no effects or even facilitatory effects have been reported on certain other tasks, e.g., involving physical strength; see Smith, 1990, for discussion of this issue) and in many cases these effects could reflect other processes than the distraction of attention (e.g., increased level of arousal). It is therefore unclear to what extent one can draw any general conclusions about attention and the ability to ignore irrelevant distractions (including those by visual stimuli) from the research examining the effects of noise.

Laboratory attention research examining the issue of interference from distractors to which no response is required has nevertheless been limited to cases of distractors that have in fact been relevant to the task in one sense or another. To illustrate this point, consider the two main distractor paradigms that have been widely used to address the effects of irrelevant distractors on attention: the flanker task (and its variations, e.g., in the study of negative priming) and the singleton attention capture task.

In a typical flanker task participants make speeded choice responses between different target stimuli (e.g., press one key to indicate that the target letter X appeared and another to indicate that a target letter N appeared) while attempting to ignore an irrelevant-distractor stimulus. Distractor processing is assessed by comparing target response times (RTs) in the presence of distractor stimuli that are either associated with the current target responses (e.g., distractor X, for a target X: a compatible distractor condition), associated with the alternative target response (e.g., distractor N for a target X: an incompatible distractor condition), or not associated with any of the target responses (a neutral distractor condition). Distractor compatibility effects on target RTs, namely, the slowing of target RTs in the presence of response-incompatible versus response-compatible or neutral distractor conditions, indicate that participants have failed to ignore the irrelevant distractor. The distractor is considered irrelevant in this paradigm because it is presented in an irrelevant location, typically in the periphery, where the target is never presented, whereas the target is typically presented at the display center (though see Beck & Lavie, 2005, for the effects of distractors when presented at fixation with the task-relevant stimuli presented at the periphery).

However, although the distractor location is irrelevant, its identity is highly relevant to the task as it is associated with one of the target responses. This paradigm is therefore limited with respect to addressing determinants of distraction by stimuli that are entirely irrelevant, namely, not only presented in irrelevant positions but also not being associated with any of the target responses.

Another popular distractor paradigm is that of "attentional capture." In this paradigm participants typically perform a visual search task, for example, search for a prespecified target letter (Jonides & Yantis, 1988; Yantis & Jonides, 1990) or shape (Theeuwes, 1992, 1994). One of the search nontarget stimuli carries a unique "singleton" feature (e.g., is the only red among otherwise all-green items in the letter or shape search tasks described above). The processing of this distractor and the extent to which it is thought to have captured attention is assessed by measuring search RTs in the presence compared to the absence of this singleton distractor. Importantly, although the attentional-capture effects are often larger when the singleton feature is in some sense relevant to the target search (Folk & Remington, 1998, 1999; Johnson, Hutchison, & Neill, 2001) attention-capture effects can found even when the distractor singleton feature appears to be irrelevant to the search task (such as is the case for a color singleton distractor presented during a shape- or letter-based search in the example mentioned above).

However, even in the later cases when the distractor is an irrelevant-feature singleton, the attentional-capture paradigm remains limited with respect to addressing determinants of distraction by stimuli that are entirely irrelevant to the task because the singleton location is typically task relevant. As the target may potentially appear in the singleton location or, in other cases (e.g., Peterson, Kramer, & Irwin, 2004; Theeuwes, Kramer, Hahn, Irwin, & Zelinsky, 1999), as the singleton is presented in a location that is perceptually grouped with the other search items' locations (e.g., they are all presented as part of one circle), participants in fact have to include this location in their search for the target. Notice that in recent temporal versions of the attentional-capture paradigm either the singleton distractor's location is relevant to the temporal search, as it is presented in the same stream as the target (Dalton & Lavie, 2004), or else, if the distractor is presented in a different stream or flanking the relevant stream stimuli, it is found to interfere only when distractor feature dimensions (e.g., color), are in fact relevant to the search target (Folk, Leber, & Egeth, 2002; Folk & Remington, 2006).

In conclusion, the existing distractor tasks do not address the important issue of what determines distraction by stimuli that are entirely irrelevant to the task at hand as they bear no response or feature relevance to the task stimuli, and appear in an irrelevant location. The purpose of the present study was therefore to establish a new distractor paradigm in which, as often is the case in daily life, the distractor stimuli may attract attention despite being entirely irrelevant to the task. To that purpose we asked participants to perform a letter-search task and indicate whether the target letter X or N has appeared in the search display. On 10% of the trials an entirely task-irrelevant distractor appeared in the periphery.

To increase sensitivity to reveal interference effects from distractors that are entirely irrelevant to the task at hand we selected stimuli with attributes that previous research suggest to be particularly attention capturing. In this sense our measure of distraction is also akin to distraction in daily life, whereby the source of distraction is often more attractive to attention than the stimuli relevant for the current task (e.g., in the aforementioned examples of distraction during driving or during office work, the billboards are often more attractive than the stimuli relevant for the driving task, such as the state of the road, and the actions of a colleague nearby may appear more attractive than office tasks such as word processing and number crunching). We therefore presented meaningful and colorful pictures of famous figures (e.g., "Spider-Man") that are likely to be familiar to all subjects and are clearly more salient (and hence likely to capture attention; see Theeuwes, 1991, 1992, 2004; Yantis & Egeth, 1999) than the monochromatic search letters in the relevant task. These were presented on a low frequency of trials again to make the distraction more akin to daily life. The cost associated with distraction by these irrelevant distractors was measured by a comparison of the search RTs in the presence versus the absence of an irrelevant distractor.

A second aim of the study was to investigate whether distraction by entirely irrelevant stimuli is determined by the same factors as those that that were found to determine distraction in previous distractor paradigms. We focused on the role of perceptual load as prescribed by the Load Theory of attention (Lavie, 1995; Lavie, Hirst, de Fockert, & Viding, 2004; Lavie & Tsal, 1994), as many studies have highlighted the level of perceptual load in a relevant task as a major determinant of the extent to which irrelevant stimuli are distracting (see Lavie, 2005 for review).

In the Load Theory perception is a capacity-limited process that proceeds in an automatic manner on all stimuli within its capacity. Thus perception of stimuli that are currently task irrelevant and can potentially be distracting cannot be voluntarily withheld. In tasks that involve only low levels of perceptual load (e.g., requiring the detection of just one stimulus) any spare capacity not taken up by the perception of task-relevant stimuli involuntarily "spills over" to the perception of task-irrelevant distractors. Distractor processing is, however, prevented in tasks of high perceptual load (e.g., tasks requiring complex perceptual discriminations or involving many relevant stimuli) as a natural consequence of the tasks exhausting all or most of the perceptual capacity in the processing of task-relevant stimuli, leaving little or none for any irrelevant-distractor processing.

Evidence in support of Load Theory has been obtained in many studies using both behavioral (e.g., Cartwright-Finch & Lavie, 2006; Lavie, 1995; Lavie & Cox, 1997; Lavie & Fox, 2000) and neuroimaging methods (e.g., Bishop, Jenkins, & Lawrence, 2006; Pinsk, Doniger, & Kastner, 2004; Rees, Frith, & Lavie, 1997; Schwartz et al., 2005; Yi, Woodman, Widders, Marois, & Chun, 2004). The results of these studies converged to show that distractor processing and related brain activity are determined by the level of perceptual load in the task in the manner predicted by the Load Theory.

Load Theory has promising applied implications, both for predicting in which situations individuals will be most susceptible to distraction (i.e., during the performance of perceptually undemanding tasks) and potentially for devising methods to aid the avoidance of distractor interference (by increasing the tasks' perceptual demands). As yet, however, it is unknown whether increasing perceptual load will eliminate interference from distractors that cause interference despite being entirely irrelevant to the task. Interference by such distractors may not be modulated by perceptual load, as it is possible that stimuli capable of capturing attention despite task irrelevance would be the kind of "special" stimuli to override the effects of perceptual load. Indeed, previous research has demonstrated that the interference from task-relevant (response-competing) distractors that are in some way more special (e.g., famous faces) was not modulated by the level of perceptual load in the task (Lavie, Ro, & Russell, 2003).

We thus varied the level of perceptual load in the letter-search task. Similarly to previous perceptual-load studies (e.g., Lavie & Cox, 1997) participants either searched for an X or N target among small Os (low perceptual load) or among other similar angular letters (H, K, M, Z, W, V, high perceptual load). In addition we have presented a compatible or incompatible distractor letter on 80% of the trials (the irrelevant-distractor picture was presented on 10% of the trials, and no distractor was presented on the remaining 10% of the trials, Experiments 1–2). The previous behavioral perceptual-load tasks used various measures of distractor processing in establishing the effects of perceptual load on distractor processing (e.g., negative priming: Lavie & Fox, 2000; recognition memory: Jenkins, Lavie, & Driver, 2005; measures of explicit awareness in inattentional blindness and change blindness paradigms: Beck, Muggleton, Walsh, & Lavie, 2006; Cartwright-Finch & Lavie, 2006; Lavie, 2006), but the flanker task is perhaps the most widely used behavioral measure of distractor processing both in the perceptual-load studies (e.g., Beck & Lavie, 2005; Lavie, 1995; Lavie & Cox, 1997; Lavie, Ro, & Russell, 2003) and in selective attention studies in general (see Lavie & Tsal, 1994 for review).

The incorporation of the flanker distractor letters into our task allowed us to ensure that the effects of perceptual load on distractor processing were replicable in our new paradigm. Such replication seemed particularly important in light of the possibility that interference by the irrelevant but meaningful distractor may not be modulated by perceptual load.

Experiment 1

Method

Participants. Sixteen participants (12 females) aged between 18 and 35 ($M = 22$), with normal or corrected-to-normal vision, were recruited from the University College London subject pool and paid for participation.

Stimuli and procedure. The experiment was programmed and run with the use of E-Prime. All stimuli were presented on a 15-in. computer screen at a viewing distance of 60 cm. Each trial began with a centrally presented fixation point for 500 ms, followed immediately by the stimulus display, which remained onscreen until response. The stimulus display consisted of a centrally presented 1.6° radius circle of six letters (each subtending 0.6° by 0.4°). In each trial the participants were required to search the letter circle for a target letter (either X or N) and respond using the numerical keypad by pressing the 0 key if the target was an X and the 2 key if the target was an N. In the high-load condition the nontarget letters in the circle were five angular letters (selected at random from H, K, M, Z, W, V) placed randomly around the circle, and in the low load the nontarget letters were all small Os (0.15°).

On 80% of the trials a distractor letter (0.8° by 0.5°) was presented to the left or right of the circle, 1.4° from the nearest circle letter. This distractor letter was equally likely to be an X or an N, and equally likely to be the same as (congruent condition) or different from (incongruent condition) the target. All stimuli were presented on a black background and all letter stimuli were gray. On 10% of the trials (irrelevant-distractor condition) a cartoon character (Pikachu from the Pokémon cartoon, Mickey Mouse, Donald Duck, Spongebob Squarepants, Superman or Spider-Man), subtending 2.8° to 4° vertically by 2.8 to 3.2° horizontally, was presented in full color, either above or below the letter circle (with its center at 4.6° from fixation, and between 0.6° and 1° edge to edge from the nearest circle letter)—see Figure 1 for a sample stimulus display with the irrelevant distractor. Note that, in order to avoid the task-irrelevant distractors acquiring some relevance through their location also being associated with task-relevant distractors, in all experiments the two types of distractors were presented in these separate locations, with irrelevant distractors presented above or below the central search display, and the task-relevant distractors presented to the left or right. On the remaining 10% trials no distractor was presented. Participants were instructed to respond as quickly as they could while being accurate and were emphatically instructed to look only at the letter circle and ignore any additional stimuli that might appear outside the circle. A short beep sounded on incorrect responses.

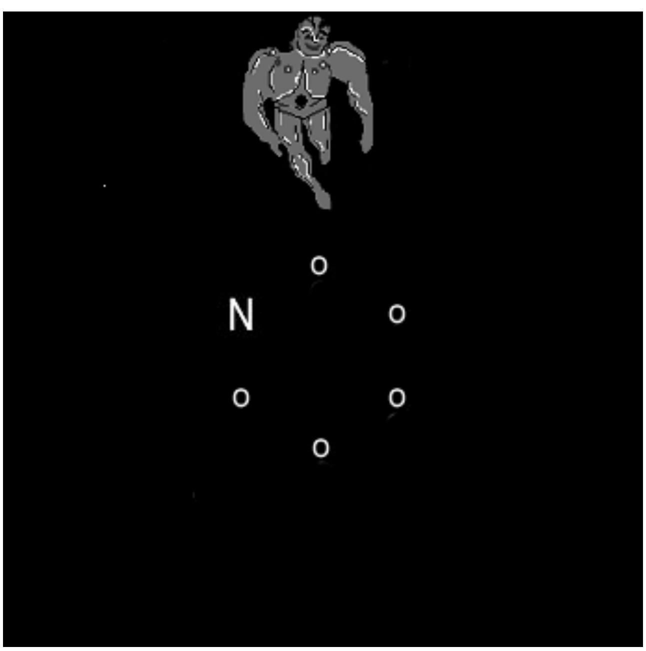

Figure 1. An example stimulus display (not to scale) with an irrelevant distractor in the low load (set size 1) condition. Note that the specific cartoon image shown here as an irrelevant distractor is included for illustrative purposes only, in order to avoid violating copyright for the images used in the experiment (these were Spongebob Squarepants, Superman, Spider-Man, Mickey Mouse, Donald Duck, and Pikachu from the Pokémon cartoon).

Participants completed three slow example trials and 12 practice trials for each level of load. The practice trials included only the congruent and incongruent conditions and participants were not informed that cartoon characters would be appearing during the experiment. Participants then completed four low-load and four high-load blocks of 60 trials in the order either ABBAABBA or BAABBAAB (counterbalanced between participants). All combinations of load, target position, target identity, distractor condition, and distractor identity were fully counterbalanced for both the high-frequency (congruent or incongruent) and the low-frequency trials (irrelevant-distractor and no-distractor conditions).

Results and Discussion

Response times. Response times longer than 2 s were considered outliers and excluded from the analyses. This led to excluding 0.2% of the low-load trials and 3.1% of the high-load trials. In order to reduce noise from guessed responses, inaccurate responses were also excluded from the RT analyses. The mean RTs in this experiment as well in Experiment 2 were calculated as a function of load and distractor condition and then entered into two 2 × 2 within-subject ANOVAs, one with the factors of load (low, high) and distractor congruency (incongruent, congruent) and the other with the factor of load (low, high) and irrelevant-distractor condition (irrelevant distractor, no distractor). Table 1 presents the mean results in the different experimental conditions.

The load × distractor-congruency ANOVA revealed a main effect for load, $F(1,15) = 154.51$, $MSE = 7{,}791.44$, $p < .001$, $\eta_p^2 = .91$. RTs were longer in the high-load than in the low-load conditions, confirming that the perceptual-load manipulation was effective in increasing the task difficulty. There was also a main effect for the distractor congruency, $F(1,15) = 4.41$, $MSE = 882.91$, $p = .053$, $\eta_p^2 = .23$, that was qualified by an interaction of load and distractor congruency, $F(1,15) = 5.19$, $MSE = 1{,}237.37$, $p = .038$, $\eta_p^2 = .26$. This interaction indicated that high perceptual load eliminated distractor-congruency effects: The distractor-congruency effects were significant only in the low-load condition [$M = 36$ ms, $t(15) = 4.18$, SEM = 8.51, $p = .001$, $d = 2.16$] and not in the high-load condition ($M = -4$, $t < 1$), thus replicating the effect of perceptual load on distractor processing established in previous research (e.g., Lavie, 1995; Lavie & Cox, 1997; see Lavie, 2005, for review).

The ANOVA with the factors of load and irrelevant-distractor conditions revealed main effects for load, $F(1,15) = 107.73$, $MSE = 12{,}927.06$, $p < .001$, $\eta_p^2 = .88$, and for the irrelevant-distractor condition, $F(1,15) = 11.05$, $MSE = 3{,}336.68$, $p = .005$, $\eta_p^2 = .42$, but no interaction of load and irrelevant-distractor condition, $F < 1$. As can be seen in Table 1, RTs were longer in the presence of an irrelevant distractor than in the no-distractor conditions in both conditions of load. The contrast between the modulation of interference from the response-related distractor letter by load and the lack of modulation of interference from the irrelevant distractor is potentially important in indicating boundary conditions for load effects on distractor processing and may be due to a number of factors that could have made the irrelevant distractor interfering regardless of load, for example, its rarity, meaningfulness, superfamiliarity, and so forth (see also Lavie et al., 2003). We further address this issue in the following experiments. For

Table 1
Experiment 1: Mean RTs (SE in parentheses) and Percentage Error Rates as a Function of Distractor Condition and Load

	Distractor condition					
	I	C	I–C	ID	ND	ID–ND
Low load						
RT (ms)	592 (17)	556 (14)	36	592 (16)	537 (17)	55
% Error	6	4		4	5	
High load						
RT (ms)	846 (30)	850 (31)	−4	880 (33)	839 (37)	41
% Error	6	5		5	5	

Note. I = incongruent distractor, C = congruent distractor, ID = irrelevant distractor, ND = no distractor.

now we can conclude that the present results clearly demonstrate the disruptive effects of an entirely task-irrelevant distractor.

Moreover, as can be seen in Table 1, RTs in the presence of an irrelevant distractor in the low-load condition were just as slow as RTs in the presence of a response-incongruent distractor, even though the irrelevant distractor was not associated with any response. Thus clearly this type of irrelevant distractor can distract people even though it appears in an irrelevant location and is entirely irrelevant to the task, not sharing any target stimulus characteristics and not being associated with any of the task responses. Note, however, that by pointing to the similar magnitude of interference effects from the irrelevant distractors and the response-competition distractors we do not intend to make a direct comparison of these very different distractor stimuli. Our intention here is simply to point out that it is possible for some forms of task-irrelevant distractors to produce robust interference effects that can be of a similar magnitude to those produced by response-incompatible distractors.

Errors. A load × distractor-congruency ANOVA on the percentage error rates revealed a main effect of congruency, $F(1,15) = 6.36$, $MSE = 7.16$, $p = .023$, $\eta_p^2 = .30$, reflecting increased error rates in the incongruent distractor condition. There were no further effects on the error measure (all Fs <1).

Experiment 2

In Experiments 2(a) and 2(b) we sought to rule out an important alternative account for the interpretation of the results from Experiment 1 in terms of eye movements instead of attention. Although orienting attention to a distractor is likely to also involve an eye movement (e.g., Kramer, Irwin, Theeuwes, & Hahn, 1999; Peterson et al., 2004; Theeuwes et al., 1999), it is important to establish that our measure of distractor cost to task performance does not merely reflect the cost due to an eye movement, but is instead due to the distraction of attention from focusing on the task. In other words, as the long exposure durations used in Experiment 1 allowed for eye movements, the RT cost associated with the distractor presence does not necessarily reflect any attentional effect but simply the time it took to move the eyes to the distractor and back to the task stimuli. In the following experiments we therefore used brief exposure durations (100 ms) of the task stimuli that preclude the possibility of eye movements to the distractor before completion of the search task. In this way any costs seen on the task RTs clearly reflect a cost due to diversion of attention rather than a cost due to the time it takes to make an eye movement to the distractor.

In daily life it is often the case that whereas the task one performs involves some time pressure, the distracting stimulus (e.g., a person appearing at your door) is present for a duration that may appear unlimited! In Experiment 2(a) we therefore attempted to examine distractibility in such situations by presenting the task stimuli for a brief duration (100 ms) but exposing the irrelevant distractor until response. Importantly, as the task stimuli were presented for a duration that is too brief to allow for an eye movement, any cost due to the distractor presence in Experiment 2(a) as well as in all the following experiments would reflect attention being distracted from focusing on the task rather than a cost due to an eye movement.

Once again we asked in Experiments 2(a) and 2(b) whether the effects of irrelevant distraction on attention to the task target can be modulated by increasing the level of perceptual load in the task.

Method

Participants. Sixteen participants (10 females) aged between 18 and 31 ($M = 21$) participated in Experiment 2(a); and 16 participants (8 females) aged between 19 and 27 ($M = 22$) participated in Experiment 2(b). All participants were recruited from the University College London subject pool, had normal or corrected-to-normal vision, and were paid for their participation.

Stimuli and procedure. The stimuli and procedure were identical to that of Experiment 1, with the following exceptions: For both experiments the target, nontarget, and distractor-letter stimuli were displayed for only 100 ms. A 2-s time window was allowed for responses, after which a beep was heard. In Experiment 2(a) the irrelevant distractor was displayed until response (as in Experiment 1), whereas in Experiment 2b the irrelevant distractor was displayed only for 100 ms.

Results and Discussion

Preliminary inspection of the data (presented in Table 2) revealed a similar pattern of results in Experiments 2(a) and 2(b), and their results are therefore described together.

Response times. As in Experiment 1, the load × congruency ANOVAs showed significant increases in RTs with high load [for Experiment 2(a): $F(1,15) = 74.54$, $MSE = 10{,}116.7$, $p < .001$, $\eta_p^2 = .83$; for Experiment 2(b): $F(1,15) = 101.99$, $MSE = 9{,}252.8$, $p < .001$, $\eta_p^2 = .87$]. The main effect of distractor congruency was significant in Experiment 2(b) [$F(1,15) = 7.02$, $MSE = 851.19$, $p = .018$, $\eta_p^2 = .32$], reflecting slowed responses in the presence of the incongruent distractor, although it did not reach significance in Experiment 2(a) [$F(1,15) = 1.77$, $MSE = 657.25$, $p = .203$, $\eta_p^2 = .11$]. More important was the finding that in both experiments, distractor congruency interacted with load [for Experiment 2(a): $F(1,15) = 13.00$, $MSE = 323.7$, $p = .003$, $\eta_p^2 = .46$; for Experiment 2(b): $F(1,15) = 8.946$, $MSE = 442.327$, $p = .009$, $\eta_p^2 = .37$]. As can be seen in Table 2, similarly to Experiment 1, this interaction reflected a significant distractor-congruency effect in the low-load condition [for Experiment 2(a), $M = 25$ ms, $t(15) = 2.80$, $SEM = 8.83$, $p = .013$, $d = 1.45$; for Experiment 2(b), $M = 35$ ms, $t(15) = 3.71$, $SEM = 9.45$, $p = .001$, $d = 1.92$],

Table 2

Experiment 2: Mean RTs (SE in Parentheses) and Percentage Error Rates as a Function of Distractor Condition and Load

	Distractor condition					
	I	C	I–C	ID	ND	ID–ND
			Experiment 2(a)			
Low load						
RT (ms)	576 (19)	551 (17)	25	581 (25)	529 (19)	52
% Error	9	5		7	7	
High load						
RT (ms)	777 (29)	784 (28)	−7	792 (36)	789 (36)	3
% Error	16	16		21	18	
			Experiment 2(b)			
Low load						
RT (ms)	569 (20)	534 (14)	35	575 (19)	514 (15)	61
% Error	8	5		8	5.5	
High load						
RT (ms)	796 (30)	793 (28)	4	816 (34)	805 (33)	11
% Error	17	17		16	16	

Note. I = incongruent distractor, C = congruent distractor, ID = irrelevant distractor, ND = no distractor.

but not in the high-load condition [for Experiment 2(a), $M = -7$ ms, $t(15) = -1.15$, $SEM = 6.68$, $p = .268$, $d = -0.59$; for Experiment 2(b), $M = 4$ ms, $t < 1$].

The ANOVAs on load × irrelevant-distractor condition also revealed main effects of load [for Experiment 2(a): $F(1,15) = 49.82$, $MSE = 887{,}585.38$, $p < .001$, $\eta_p^2 = .77$; for Experiment 2(b): $F(1,15) = 107.57$, $MSE = 10{,}502.64$, $p < .001$, $\eta_p^2 = .88$], and irrelevant-distractor condition [for Experiment 2(a): $F(1,15) = 7.61$, $MSE = 12{,}031.9$, $p = .015$, $\eta_p^2 = .34$; for Experiment 2(b): $F(1,15) = 26.39$, $MSE = 20{,}476.54$, $p < .001$, $\eta_p^2 = .64$], mirroring the effects observed in Experiment 1. However, in a contrast to Experiment 1, there was also an interaction of load and irrelevant-distractor condition [for Experiment 2(a): $F(1,15) = 4.52$, $MSE = 2{,}073.54$, $p = .051$, $\eta_p^2 = .23$; for Experiment 2(b): $F(1,15) = 5.82$, $MSE = 1{,}681.18$, $p = .029$, $\eta_p^2 = .28$]. This interaction indicated that the significant RT cost due to the presence (vs. absence) of an irrelevant distractor in the low-load condition [for Experiment 2(a): $M = 52$ ms, $t(15) = 3.54$, $SEM = 14.58$, $p = .002$, $d = 1.83$; for Experiment 2(b): $M = 61$ ms, $t(15) = 8.18$, $SEM = 7.4$, $p < .001$, $d = 4.22$] was eliminated with high load ($t < 1$ for the distractor effects with high load in both experiments).

As can be seen in Table 2, with low perceptual load, RTs in the presence of the irrelevant distractor were just as slow as in the presence of the incongruent distractor ($t < 1$ for their difference).

Errors. Load × congruency ANOVAs on percentage error rates revealed a main effect of load [for Experiment 2(a): $F(1,15) = 22.83$, $MSE = 15.00$, $p < .001$, $\eta_p^2 = .60$; for Experiment 2(b): $F(1,15) = 41.8$, $MSE = 43.22$, $p < .001$, $\eta_p^2 = .74$], reflecting less-accurate performance in the high-load condition. In addition, there was a main effect of distractor congruency [for Experiment 2(a): $F(1,15) = 7.67$, $MSE = 1.00$, $p = .014$, $\eta_p^2 = .34$; for Experiment 2(b): $F(1,15) = 5.23$, $MSE = 8.08$, $p = .037$, $\eta_p^2 = .26$], due to reduced accuracy in the incongruent-distractor condition. The load × congruency interaction was not significant [for Experiment 2(a): $F(1,15) = 3.88$, $MSE = 1.00$, $p = .068$, $\eta_p^2 = .21$; for Experiment 2(b): $F(1,15) = 3.2$, $MSE = 7.06$, $p = .094$, $\eta_p^2 = .18$] but showed a trend mirroring the RTs, with greater performance costs due to incongruent distractors in the low-load condition.

Load × irrelevant-distractor conditions ANOVAs on percentage error rates revealed a main effect of load [for Experiment 2(a): $F(1,15) = 39.41$, $MSE = 6.00$, $p < .001$, $\eta_p^2 = .72$; for Experiment 2(b): $F(1,15) = 48.07$, $MSE = 26.22$, $p < .001$, $\eta_p^2 = .76$], reflecting a higher percentage of errors in the high-load condition. No other effects on the error measure were significant [for the main effect of distractor, $F < 1$; for the load × distractor interaction for Experiment 2(a), $F(1,15) = 1.68$, $MSE = 3.00$, $p = .214$, $\eta_p^2 = .10$; for Experiment 2(b), $F < 1$].

Between-experiments analyses. Mixed 2 × 2 × 2 ANOVAs on RTs to correct trials and percentage errors, with the between-subjects factor of experiment [2(a), 2(b)] and the within-subjects factors of load (low, high) and congruency (incongruent, congruent) revealed no interactions with experiment (all Fs <1 except for the experiment and congruency RT interaction for which $F(1,30) = 1.24$, $MSE = 754.22$, $p = .275$, $\eta_p^2 = .04$).

Mixed 2 × 2 × 2 ANOVAs on RTs to correct trials and percentage errors, with the between-subjects factor of experiment [2(a), 2(b)] and the within-subjects factors of load (low, high) and irrelevant-distractor condition (irrelevant distractor, no distractor) revealed no interactions with experiment [all Fs < 1, except for the interaction of load and experiment in the error data for which $F(1,30) = 2.35$, $MSE = 44.83$, $p = .136$, $\eta_p^2 = .07$, and the interaction of load, congruency, and experiment in the errors for which $F(1,30) = 1.96$, $MSE = 32.8$, $p = .172$, $\eta_p^2 = .06$]. These between-experiment analyses confirmed that the results in Experiments 2(a) and 2(b) were not statistically different.

As the results of Experiment 2(a) and 2(b) were very similar and the design of Experiment 2(b) precluded an alternative account of the results in terms of eye movements for the cost in performance produced by the presence of a distractor, these experiments suggest that the presence of an irrelevant distractor has distracted attention from focusing on the task. Importantly, now that the task stimuli were always exposed for a brief duration, the interference effects from the irrelevant distractor were eliminated with high perceptual load in the task.

It is of particular interest to note that even the effects of the prolonged distractors in Experiment 2(a) which, like many daily life distractors, continued to be present for a longer period of time than the 100-ms task presentation, were eliminated by high perceptual load. This suggests that the time pressure of the task, but not the duration of the distractor itself, affects the level of distraction.

Experiment 3

Experiments 2(a) and 2(b) demonstrated perceptual load modulation of the effects of both the irrelevant distractors and the response-competing distractors. There are a number of ways, however, in which the inclusion of response-relevant distractors in the paradigm might influence the processing of the task-irrelevant distractor. For example, the need to reject the response-competing distractors (as in some cases, when they were incongruent with the target, these were clearly directly interfering with the task response) may have motivated the subjects to make their best attempt to ignore any distractors, including the task-irrelevant distractors. Thus the irrelevant-distractor interference effects seen in the conditions of low perceptual load may have underestimated their interference in circumstances when subjects may not be as motivated to ignore irrelevant distractors. Conversely, the presence of response-competition distractors may have increased the irrelevant-distractor interference effects seen in the low-load condition because of the demand on executive control made by the rejection of the response-competition distractors, leaving executive control less able to control also for the interference from the irrelevant distractors.

It was therefore important to show that the interference from the irrelevant distractors does not depend on the presence of response-relevant distractors on the majority of the trials. Experiments 3 and 4 thus sought to establish the interference effects from irrelevant distractors as well as the effects of perceptual load in a task paradigm that does not include any response-relevant distractor.

Method

Participants. Sixteen participants (9 females) aged between 18 and 32 ($M = 21$) were recruited from the University College London subject pool and paid for their participation. All participants had normal or corrected-to-normal vision.

Stimuli and procedure. The stimuli and procedure were identical to that of Experiment 2(b), with the exception that there were no incongruent or congruent letter distractors. An irrelevant-picture distractor was displayed on 10% of the trials and no distractor was displayed on the remaining 90% of trials.

Results and Discussion

The mean RTs in this experiment as well as in Experiment 4 were calculated as a function of load and distractor condition and then entered into two 2 × 2 within-subject ANOVAs, with these factors.

Response times. The RT ANOVA revealed a main effect of load, $F(1,15) = 49.48$, $MSE = 12{,}351.79$, $p < .001$, $\eta_p^2 = .77$, as before responses were slower with high perceptual load. As in Experiment 2, there was a significant main effect of irrelevant-distractor condition, $F(1,15) = 26.42$, $MSE = 945.02$, $p = .001$, $\eta_p^2 = .64$, that was qualified by an interaction with load, $F(1,15) = 6.84$, $MSE = 947.19$, $p = .019$, $\eta_p^2 = .31$. Table 3 shows that this interaction reflected, as before, that the significant RT cost due to the presence (vs. absence) of the irrelevant distractor under low perceptual load [$M = 60$ ms, $t(15) = 7.61$, $SEM = 7.84$, $p < .001$, $d = 3.93$] was eliminated with high perceptual load [$M = 19$, $t(15) = 1.47$, $SEM = 13.23$, $p = .164$, $d = 0.75$].

Errors. A load × irrelevant-distractor condition ANOVA revealed a main effect of load, $F(1,15) = 26.82$, $MSE = 65.38$, $p < .001$, $\eta_p^2 = .64$, reflecting less accurate performance under high perceptual load. There were no other significant effects on this measure (all Fs <1).

Experiment 4

In Experiment 4 we sought to establish further the effect of perceptual load on interference by the irrelevant distractors in a design that rules out an important alternative account for the results. One might claim that the change of the task from low load to high load has also, by changing the availability of certain search strategies, changed the relevance of the supposedly entirely irrelevant distractors to the attentional settings for the search task. Recall that in the low-load conditions participants searched for an angular target letter among curved nontarget letters. The target letter therefore had a unique angular feature, and formed a singleton in the low-load conditions. In the high-load conditions the nontargets were also angular, and so the angular target was no longer a unique singleton.

One might claim, then, that although the subjects had to search for the specific target features in the high-load condition, in the low-load condition, rather than focusing on the specific angular target features, the participants instead have adopted a general search strategy whereby they simply look for any singleton in the search array (a singleton-detection strategy; see Bacon & Egeth, 1994). Such a singleton-detection search strategy would allow the subject to detect the singleton target in the low-load condition but, as the irrelevant distractor was also a singleton (the cartoon image was the only one in the display of its kind), the use of a singleton-detection strategy in the low-load task may have increased the relevance of the distractor to the attentional settings used in the low-load (but not high load) task. In other words, if the participants

Table 3
Experiment 3: Mean RTs (SE in Parentheses) and Percentage Error Rates as a Function of Distractor Condition and Load

	Distractor condition		
	ID	ND	ID–ND
Low load			
RT (ms)	538 (16)	478 (12)	60
% Error	10	7	
High load			
RT (ms)	713 (41)	694 (33)	19
% Error	19	19	

Note. ID = irrelevant distractor, ND = no distractor.

engaged in a singleton-detection search mode in the low-load condition they may have been more likely to detect the distractor by virtue of being tuned to detect any odd singleton item in this condition.

It was therefore important to establish that both the distractor interference effects found under low load and their elimination under high load did not depend on the use of a singleton-detection strategy in the low- but not high-load condition. To prevent the use of a singleton-detection strategy in the low-load condition of Experiment 4 we replaced two of the Os in the low-load displays with two, angular nontarget letters (from the set H, K, M, Z, W, V). A search set size of three target letters should not impose sufficient perceptual load to exhaust full capacity (this is typically exhausted with five items or more, e.g., Fisher, 1982; Kahneman, Treisman, & Gibbs, 1992; Pylyshyn et al., 1994; Yantis & Jones, 1991) and therefore should still be open to the processing of an additional irrelevant distractor (Lavie & Cox, 1997), but in the presence of two other angular letters the target is no longer a singleton. Thus a singleton target detection strategy would no longer be available with the addition of two angular letters to the search display in the low-load condition.

In addition, the previous experiments varied the level of perceptual load between different blocks of trials. Such a blocked design may be open to alternative accounts in terms of different expectations prior to each of the load conditions, and therefore different levels of motivation used in the different conditions of load. For example, the participants may have anticipated that the task would be harder in the high-load condition and thus been more motivated to ignore irrelevant distractors in the high-load compared to the low-load blocks. If this were the case then one might attribute the reduced distraction to the greater motivation instead of the higher perceptual load in those blocks. In order to further rule out such an alternative account of the load effects in terms of differences in expectations between the low- and high-load conditions we varied the level of perceptual load at random between different trials of the same block in Experiment 4. In this way the participants could not have anticipated or prepared for the level of perceptual load that would be presented on each trial. Thus any effects found could not be attributed to a change in the anticipated level of task load and any potential change in the participants' motivation.

Method

Participants. Sixteen participants (6 males) aged between 19 and 29 ($M = 25$), and with normal or corrected-to-normal vision, were recruited from the University College London Psychology Subject Pool and paid for their participation.

Stimuli and procedure. The stimuli in the high-load condition were identical to those in Experiment 3. In low-load condition the target letter was presented with three small Os (0.15°) and two angular nontarget letters of the same dimensions as the target (from the set H, K, Z, W, V, M). The target X or N always appeared next to the angular nontarget letters and the three angular letters (the target and two nontargets) were equally likely to appear in each of the three possible arrangements (target between the two nontargets, target to the left of both nontargets, target to the right of both nontargets). The procedure was similar to that of Experiment 3, with the following exceptions: The conditions of load were mixed within each block of 60 trials. In addition, the irrelevant distractor was displayed on 20% of the trials and no distractor was displayed on the remaining 80% of trials. For the no-distractor trials, target identity, target position, load, and their combinations were counterbalanced within each block. For the irrelevant-distractor trials, target identity and position, distractor identity and position, load, and their combinations were fully counterbalanced between blocks. Participants performed 12 slow example trials and 24 practice trials, followed by eight experimental blocks.

Results and Discussion

Response times. The 2 × 2 within-subjects ANOVA revealed significant main effects of load, $F(1,15) = 34.12$, $MSE = 2{,}464.5$, $p < .001$, $\eta_p^2 = .70$, and irrelevant-distractor condition, $F(1,15) = 6.59$, $MSE = 541.33$, $p = .021$, $\eta_p^2 = .31$. As in Experiments 2 and 3, there was also a significant interaction between load and irrelevant-distractor condition, $F(1,15) = 7.79$, $MSE = 186.53$, $p = .014$, $\eta_p^2 = .34$, as can be seen in Table 4. This interaction indicated as before that the significant RT cost due to the presence (vs. absence) of the irrelevant distractor under low perceptual load [$M = 25$ ms, $t(15) = 4.93$, $SEM = 4.97$, $p < .001$, $d = 2.55$] was eliminated with high perceptual load ($M = 6$ ms, $t < 1$).

Errors. A load × irrelevant-distractor condition ANOVA revealed only a main effect of load, $F(1,15) = 45.27$, $MSE = 41.56$, $p < .001$, $\eta_p^2 = .75$, reflecting less accurate performance under high perceptual load (all other Fs < 1).

General Discussion

The present experiments established a new laboratory measure of distractor interference from an entirely irrelevant distractor. Unlike the most commonly used measures of distractor interference, the response-competition and attentional-capture paradigms, the irrelevant distractors used here were entirely irrelevant to the task. Not only did the irrelevant cartoon images bear no association with any of the task responses (cf. the response-competition paradigm) but also they were presented in an irrelevant remote location outside of the search array. Yet they produced interference on the current task that was of equal magnitude to that from the response-competing distractor letters. The results of Experiment 4 further clarified that the interference from the irrelevant distractors cannot be attributed to a singleton-detection search strategy, as they persist even when searching for a nonsingleton target.

Table 4
Experiment 4: Mean RTs (SE in Parentheses) and Percentage Error Rates as a Function of Distractor Condition and Load

	Distractor condition		
	ID	ND	ID–ND
Low load			
RT (ms)	740 (16)	715 (28)	25
% Error	9	9	
High load			
RT (ms)	803 (37)	797 (37)	6
% Error	20	20	

Note. ID = irrelevant distractor, ND = no distractor.

Our findings also extend the interruption-management literature, demonstrating interference from interruptions that clearly require no response (as participants were instructed to ignore all material other than the search set). Thus our new measure of interference from an entirely irrelevant distractor in the present study appears to be more akin to the daily life experience of being distracted by a stimulus that is entirely unrelated to the task at hand and clearly requires no response, as in the examples discussed in the introduction of distraction by colleagues in the work environment and by billboards during driving.

The second key finding of the present study concerned the effect of perceptual load on the interference by irrelevant distractors. Perceptual load has previously been shown to modulate distractor processing under a wide range of paradigms (see Lavie, 2005 for review). The present study extends previous research first in showing that the interference by distractor stimuli that are competing with the current task response can be eliminated with high perceptual load even when both the task stimuli and the distractors are presented until response. Second, the present study demonstrates that perceptual load can also eliminate the rather sizable interference effects produced by the irrelevant-distractor cartoons as long as there is time pressure on the task performance and the stimulus durations preclude eye movements (cf. Experiment 1). Moreover, Experiment 4 ruled out alternative explanations of the perceptual-load effects in terms of a difference in the search strategy employed in the high- and low-load condition, as both levels of load required the participant to search for the distractor among other angular letters and the level of load in each trial was unpredictable.

As the irrelevant distractors we have used were images of famous cartoon figures, the finding that high perceptual load eliminates their interference might at first sight appear to conflict with the previous finding (Lavie et al., 2003) that the interference effects that famous distractor faces (of pop stars or politicians) produce are not modulated by perceptual load. However, the distractor faces in Lavie et al. (2003) were associated with the task responses (participants classified pop stars and politicians' names while their faces were presented as distractors) and their interference effects were measured through the response-competition effects produced by incongruent (e.g., Elvis Presley's face presented with Bill Clinton's name) compared to congruent (e.g., Elvis Presley's face presented with his own name) distractor faces. It therefore remains possible that the interference from the irrelevant cartoon distractors of the present study would be unaffected by perceptual load if they became task relevant (e.g., if the task involved classification of their names).

In the present study, in order to examine whether stimuli entirely irrelevant to the task at hand could, nevertheless, be distracting, we elected to use distractors with characteristics (visual salience, meaningfulness) that previous research suggests to be highly distracting. Future research should establish the necessary and sufficient conditions for interference by distractors that are entirely irrelevant to the task (e.g., would the distracting effects persist even when the irrelevant distractors were meaningless and displayed on a greater percentage of trials? Would irrelevant distractors produce greater interference effects if presented in another modality to the task stimuli? Can task-irrelevant distractors produce interference even if they are of equal or lower salience relative to the task stimuli?). Such research is currently under way in our lab.

Finally, the present research has promising practical implications for determining the situations in which people are particularly susceptible to distraction in daily life. The results of Experiment 1 suggest that when there is no time pressure on a task currently being performed, individuals may remain susceptible to distraction from salient yet irrelevant distractors, regardless of the perceptual demands of the task they are performing. On the other hand, the results of Experiments 2–4 suggest that when there is time pressure on a task being performed, people are less likely to become distracted [even, as the results of Experiment 2(a) would suggest, by the prolonged presence of a distractor] if their task has a high level of perceptual load.

These findings would thus predict that drivers may be less susceptible to distraction from salient billboards while weaving in and out of heavy traffic (high perceptual load) than when driving along an empty motorway (low perceptual load). For work environments the findings would suggest that the design of some tasks may benefit from involving higher perceptual load so that employees would be less distracted by task-irrelevant stimuli.

In addition to these apparently beneficial effects of perceptual load, future research may also examine the effect of increased perceptual load in contexts within which reduced awareness of distractors would not be beneficial. For example, although people may better ignore irrelevant distractors in tasks of high perceptual load they may also be less able to disengage from the task and make a response to a relevant interruption in such tasks. Thus, in cases where effective interruption management is likely to require a swift response it may prove beneficial to minimize the level of perceptual load in the task involved. Overall, the present research highlights the importance of considering the interference effects of distractors that are entirely task irrelevant and the role of perceptual load in determining such distraction.

References

Arthur, W., & Doverspike, D. (1992). Locus of control and auditory selective attention as predictors of driving accident involvement—A comparative longitudinal investigation. *Journal of Safety Research, 23,* 73–80.

Bacon, W. F., & Egeth, H. E. (1994). Overriding stimulus-driven attentional capture. *Perception & Psychophysics, 55,* 485–496.

Beck, D. M., & Lavie, N. (2005). Look here but ignore what you see: Effects of distractors at fixation. *Journal of Experimental Psychology—Human Perception and Performance, 31,* 592–607.

Beck, D. M., Muggleton, N., Walsh, V., & Lavie, N. (2006). Right parietal cortex plays a critical role in change blindness. *Cerebral Cortex, 16,* 712–717.

Bishop, S. J., Jenkins, R., & Lawrence, A. D. (2006). Neural processing of fearful faces: Effects of anxiety are gated by perceptual capacity limitations. *Cerebral Cortex, 17,* 1595–1603.

Broadbent, D. E. (1979). Human performance and noise. In C. M. Harris (Ed.), *Handbook of noise control* (pp. 2066–2085). New York: McGraw-Hill.

Cartwright-Finch, U., & Lavie, N. (2006). The role of perceptual load in inattentional blindness. *Cognition, 102,* 321–340.

Dalton, P., & Lavie, N. (2004). Auditory attentional capture: Effects of singleton distractor sounds. *Journal of Experimental Psychology—Human Perception and Performance, 30,* 180–193.

Fisher, D. L. (1982). Limited-channel models of automatic detection:

Capacity and scanning in visual search. *Psychological Review, 89,* 662–692.

Folk, C. L., Leber, A. B., & Egeth, H. E. (2002). Made you blink! Contingent attentional capture produces a spatial blink. *Perception & Psychophysics, 64,* 741–753.

Folk, C. L., & Remington, R. (1998). Selectivity in distraction by irrelevant featural singletons: Evidence for two forms of attentional capture. *Journal of Experimental Psychology—Human Perception and Performance, 24,* 847–858.

Folk, C. L., & Remington, R. (1999). Can new objects override attentional control settings? *Perception & Psychophysics, 61,* 727–739.

Folk, C. L., & Remington, R. (2006). Top-down modulation of preattentive processing: Testing the recovery account of contingent capture. *Visual Cognition, 14,* 445–465.

Gillie, T., & Broadbent, D. (1989). What makes interruptions disruptive—A study of length, similarity, and complexity. *Psychological Research—Psychologische Forschung, 50,* 243–250.

Hodgetts, H. M., & Jones, D. M. (2006). Interruption of the tower of London task: Support for a goal-activation approach. *Journal of Experimental Psychology—General, 135,* 103–115.

Jackson, T., Dawson, R., & Wilson, D. (2003). Reducing the effect of email interruptions on employees. *International Journal of Information Management, 23,* 55–65.

Jenkins, R., Lavie, N., & Driver, J. (2005). Recognition memory for distractor faces depends on attentional load at exposure. *Psychonomic Bulletin & Review, 12,* 314–320.

Johnson, J. D., Hutchison, K. A., & Neill, W. T. (2001). Attentional capture by irrelevant color singletons. *Journal of Experimental Psychology—Human Perception and Performance, 27,* 841–847.

Jones, G. V., & Martin, M. (2003). Individual differences in failing to save everyday computing work. *Applied Cognitive Psychology, 17,* 861–868.

Jonides, J., & Yantis, S. (1988). Uniqueness of abrupt visual onset in capturing attention. *Perception & Psychophysics, 43,* 346–354.

Kahneman, D., Treisman, A., & Gibbs, B. J. (1992). The reviewing of object files—Object-specific integration of information. *Cognitive Psychology, 24,* 175–219.

Kramer, A. F., Irwin, D. E., Theeuwes, J., & Hahn, S. (1999). Oculomotor capture by abrupt onsets reveals concurrent programming of voluntary and involuntary saccades. *Behavioral and Brain Sciences, 22,* 689–690.

Larson, G. E., Alderton, D. L., Neideffer, M., & Underhill, E. (1997). Further evidence on dimensionality and correlates of the Cognitive Failures Questionnaire. *British Journal of Psychology, 88,* 29–38.

Larson, G. E., & Merritt, C. R. (1991). Can accidents be predicted—An empirical test of the Cognitive Failures Questionnaire. *Applied Psychology—An International Review—Psychologie Appliquee—Revue Internationale, 40,* 37–45.

Latorella, K. A. (1998). Effects of modality on interrupted flight deck performance: Implications for data link. In *Proceedings of the Human Factors and Ergonomics Society 42nd Annual Meeting*.

Lavie, N. (1995). Perceptual load as a necessary condition for selective attention. *Journal of Experimental Psychology—Human Perception and Performance, 21,* 451–468.

Lavie, N. (2006). The role of perceptual load in visual awareness. *Brain and Research, 1080*(1), 91–100.

Lavie, N. (2005). Distracted and confused?: Selective attention under load. *Trends in Cognitive Sciences, 9,* 75–82.

Lavie, N., & Cox, S. (1997). On the efficiency of visual selective attention: Efficient visual search leads to inefficient distractor rejection. *Psychological Science, 8,* 395–398.

Lavie, N., & Fox, E. (2000). The role of perceptual load in negative priming. *Journal of Experimental Psychology—Human Perception and Performance, 26,* 1038–1052.

Lavie, N., Hirst, A., de Fockert, J. W., & Viding, E. (2004). Load theory of selective attention and cognitive control. *Journal of Experimental Psychology—General, 133,* 339–354.

Lavie, N., Ro, T., & Russell, C. (2003). The role of perceptual load in processing distractor faces. *Psychological Science, 14,* 510–515.

Lavie, N., & Tsal, Y. (1994). Perceptual load as a major determinant of the locus of selection in visual-attention. *Perception & Psychophysics, 56,* 183–197.

McEvoy, S. P., Stevenson, M. R., & Woodward, M. (2007). The prevalence of, and factors associated with, serious crashes involving a distracting activity. *Accident Analysis and Prevention, 39,* 475–482.

McFarlane, D. C., & Latorella, K. A. (2002). The scope and importance of human interruption in human–computer interaction design. *Human–Computer Interaction, 17,* 1–61.

Noy, Y. I., Lemoine, T. L., Klachan, C., & Burns, P. C. (2004). Task interruptability and duration as measures of visual distraction. *Applied Ergonomics, 35,* 207–213.

Peterson, M. S., Kramer, A. F., & Irwin, D. E. (2004). Covert shifts of attention precede involuntary eye movements. *Perception & Psychophysics, 66,* 398–405.

Pinsk, M. A., Doniger, G. M., & Kastner, S. (2004). Push–pull mechanism of selective attention in human extrastriate cortex. *Journal of Neurophysiology, 92,* 622–629.

Pylyshyn, Z., Burkell, J., Fisher, B., Sears, C., Schmidt, W., & Trick, L. (1994). Multiple parallel access in visual-attention. *Canadian Journal of Experimental Psychology—Revue Canadienne de Psychologie Experimentale, 48,* 260–283.

Rabiner, D. L., Murray, D. W., Schmid, L., & Malone, P. S. (2004). An exploration of the relationship between ethnicity, attention problems, and academic achievement. *School Psychology Review, 33,* 498–509.

Rees, G., Frith, C. D., & Lavie, N. (1997). Modulating irrelevant motion perception by varying attentional load in an unrelated task. *Science, 278,* 1616–1619.

Schwartz, S., Vuilleumier, P., Hutton, C., Maravita, A., Dolan, R. J., & Driver, J. (2005). Attentional load and sensory competition in human vision: Modulation of fMRI responses by load at fixation during task-irrelevant stimulation in the peripheral visual field. *Cerebral Cortex, 15,* 770–786.

Smith, A. (1990). Noise, performance efficiency and safety. *International Archives of Occupational and Environmental Health, 62,* 1–5.

Strayer, D. L., & Drews, F. A. (2007). Cell-phone-induced driver distraction. *Current Directions in Psychological Science, 16,* 128–131.

Teichner, W. H., Arees, E., & Reilly, R. (1963). Noise and human performance, a psychophysiological approach. *Ergonomics, 6,* 83–97.

Theeuwes, J. (1991). Cross-dimensional perceptual selectivity. *Perception & Psychophysics, 50,* 184–193.

Theeuwes, J. (1992). Perceptual selectivity for color and form. *Perception & Psychophysics, 51,* 599–606.

Theeuwes, J. (1994). Stimulus-driven capture and attentional set—Selective search for color and visual abrupt onsets. *Journal of Experimental Psychology—Human Perception and Performance, 20,* 799–806.

Theeuwes, J. (2004). Top-down search strategies cannot override attentional capture. *Psychonomic Bulletin & Review, 11,* 65–70.

Theeuwes, J., Kramer, A. F., Hahn, S., Irwin, D. E., & Zelinsky, G. J. (1999). Influence of attentional capture on oculomotor control. *Journal of Experimental Psychology—Human Perception and Performance, 25,* 1595–1608.

Trafton, J. G., Altmann, E. M., Brock, D. P., & Mintz, F. E. (2003). Preparing to resume an interrupted task: Effects of prospective goal encoding and retrospective rehearsal. *International Journal of Human–Computer Studies, 58,* 583–603.

Wallace, B. (2003). Driver distraction by advertising: Genuine risk or urban myth? *Proceedings of the Institution of Civil Engineers—Municipal Engineer, 156,* 185–190.

Wallace, J. C., & Vodanovich, S. J. (2003). Can accidents and industrial mishaps be predicted? Further investigation into the relationship between cognitive failure and reports of accidents. *Journal of Business and Psychology, 17,* 503–514.

Yantis, S., & Egeth, H. E. (1999). On the distinction between visual salience and stimulus-driven attentional capture. *Journal of Experimental Psychology—Human Perception and Performance, 25,* 661–676.

Yantis, S., & Jones, E. (1991). Mechanisms of attentional selection—Temporally modulated priority tags. *Perception & Psychophysics, 50,* 166–178.

Yantis, S., & Jonides, J. (1990). Abrupt visual onsets and selective attention—Voluntary versus automatic allocation. *Journal of Experimental Psychology—Human Perception and Performance, 16,* 121–134.

Yi, D. J., Woodman, G. F., Widders, D., Marois, R., & Chun, M. M. (2004). Neural fate of ignored stimuli: Dissociable effects of perceptual and working memory load. *Nature Neuroscience, 7,* 992–996.

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